

CHAPTER 4

GENERAL CRITERIA AND DESIGN FEATURES TO ENHANCE DECOMMISSIONING

4-1. Site planning criteria

Since the magnitude of a decommissioning effort will vary greatly as a function of the type of facility being decommissioned, provisions for site planning to facilitate a decommissioning must be addressed on a site-specific basis. Presented below are items that should be considered in the conceptual site plan for a nuclear facility in order to support its ultimate decommissioning.

a. Waste Storage. A convenient location at or near the decommissioning site should be provided for temporary storage of LLW that is awaiting shipment for disposal. Factors affecting the location of this holding area are as follows:

- (1) It should be distant from areas having uncontrolled access and able to be secured fenced and monitored for access control.
- (2) It should permit the erection of any required temporary shielding.
- (3) It should permit access of transport vehicles and cranes.
- (4) Although not required, it should be close to the decommissioning area.
- (5) The area should be located such that drainage from the surrounding areas does not result in the accumulation of water at the storage site. The storage site itself should be level, on impermeable soil and able to be graded to collect spilled contaminants. An optimum situation is one where the site is relatively flat; outside the site, a drop in grade occurs in all directions from the storage area perimeter.

(6) A detailed discussion on radwaste handling requirements is provided later in this chapter which includes additional site planning considerations.

b. Process Equipment. Space should be provided in the immediate area of the facility to be decommissioned to allow the placement of temporary process equipment such as solidification, volume reduction, and decontamination systems. Factors to be addressed in locating these areas are as follows:

- (1) The area should be graded to ensure confinement of accidental spills of LLW.
- (2) Area should be located close to the tie-in points within the facility in order to minimize extensive runs of temporary piping.
- (3) Sufficient space should be provided to allow cranes to be used in placing and removing the temporary equipment as well as the removal of containers of processed waste. These waste containers could be as large as 200 cubic feet and weigh as much as 20,000 pounds.

(4) A detailed discussion on site requirements for decontamination methods is provided in Section 4-7.

b. General Consideration. Other site planning criteria are given below.

(1) Access by cranes should be ensured to those areas of the facility that have roof or wall sections that have to be removed to permit equipment removal.

(2) Separate laydown areas should be provided for material that must undergo a radiation survey to determine if it is clean or must be handled as LLW.

(3) The site must be readily accessible to the various types of equipment and vehicles needed for the decommissioning effort. This could include heavy-duty trucks, bulldozers, cranes, and earthmoving equipment.

(4) Roads, waterways, and railroads in the area of the facility must be evaluated to ensure that at decommissioning it will be physically possible to remove contaminated materials. New roads must meet these design requirements. For example, large clearance and load requirements of the access route, although not needed during operation, may be needed during decommissioning.

(5) The location and routing of utilities (fire, sewage, potable water, etc.) must be established to ensure that service can be continued during decommissioning.

4-2. Conceptual design considerations

Criteria provided in the following sections are for specific design areas such as mechanical or electrical systems, or for specific types of facilities. General guidance to be considered during the planning and concept development of a facility follow.

a. Decommissioning Plan. A planned approach to decommissioning the facility should be established concurrently with the development of the facility concept design and the two should complement each other. Reference chapter 6 for a complete discussion of decommissioning plans. Safety and cost implications during construction, over the expected life of the facility, and during decommissioning should be considered. A concept which optimizes decommissioning efforts may result in greater design and construction costs, but has the potential for lower operational costs and enhanced safety. A facility concept which is developed to optimize construction and operational costs only may result in a facility which is difficult and expensive to decommission. To bring a balance between these factors, decommissioning should be considered as an important part of the life cycle of the facility. Life-cycle costs

analyses which weigh both immediate and deferred expenses should be conducted. As part of this effort, the following actions should be taken:

(1) Evaluation of various decommissioning alternatives and decontamination methods appropriate for the planned facility. This includes an assessment of the type and extent of contamination expected over the lifetime of the facility.

(2) Identification of any actions that must be performed before any of the decommissioning options can be implemented.

(3) Identification of design features that would facilitate decontamination and waste processing activities that would be performed in support of a decommissioning program.

(4) Development of the facility floor plan and selection of systems to allow isolation of areas where contamination is expected thus avoiding contaminant spread to other areas and minimizing cleanup efforts.

(5) Consideration of design features that would serve to facilitate both decommissioning at the termination of operations and maintenance and cleaning of contaminated areas during operations. The better maintained and decontaminated the facility is kept during its lifetime, the easier decommissioning can be performed.

b. Decommissioning Technology. The following should be considered during facility concept development:

(1) Assurance that the use of current technology is not precluded by the design criteria. The need to decontaminate due to an accident or even decommission may occur at any time, even shortly after facility startup. Therefore, technology available during the initial design effort may be the only technology that can be used for decommissioning.

(2) Avoidance, to the extent feasible, of reliance on only one specific decommissioning approach. It is possible that the recommended decommissioning approach would become outdated and not acceptable for use at the end of the facility's life.

4-3. Architectural and structural design criteria

The following is a summary of general architectural and structural design options.

a. Walls, Floors, and Ceilings. Surfaces should be smooth and coated, sealed, or provided with a surface liner to prevent contaminants from penetrating the materials of construction.

(1) Floor covering should be totally seamless, if possible. If not, the number of seams must be kept to a minimum. The use of tile segments should be avoided.

(2) Coatings and sealers should comply with the specifications of ANSI N512 of the American National Standards Institute and be selected for high impermeability.

(3) Cracks, crevices, and joints should be sealed to prevent the entrapment or spread of contaminants.

(4) Curbs, dikes, or other barriers should be provided

to contain potential releases of radioactive liquids. The net containment volume should be at least 125 percent of the total volume of liquid contained in the area.

(5) Floors should slope toward floor drains. This will reduce the spread of contaminants resulting from accidental release or spill and aid in the cleanup.

(6) Repeated decontamination during operations of covered or sealed surfaces should not reduce the effectiveness of the barrier. The barrier should be capable of being returned to its original effectiveness or be replaced after DECON before exposure to contaminants.

(7) Layered or porous materials that could entrap radioactive materials should not be used.

(8) Walls or other barriers with interior spaces should be sealed.

(9) Materials used on walls, floors, or ceilings that cannot be easily decontaminated should be easy to remove and dispose.

(10) The edges of the floors where they meet the walls should be easy to clean and decontaminate and shall be well sealed and easily maintained to prevent dust or liquid seepage into construction joints.

(11) There should be a minimum of protuberances from the walls, floors, and ceilings inside or upon which dust can settle.

(12) Block walls should not be used in areas where surface contamination can be expected to occur over the life of the facility. However, block walls may be used if it can be ensured that the finished surface is sealed and maintained to be smooth, nonporous, and easily decontaminable.

(13) Drop ceilings or interstitial spaces are not allowed where contamination of space is anticipated.

(14) Materials should be chosen which have a low probability of activation for the operations to be performed at the facility.

b. Penetrations. The number of wall, ceiling, and floor penetrations should be kept to a minimum and, wherever possible, located near each other.

(1) In an ideal situation, a well sealed, removable penetration panel would be used through which all electrical, plumbing and mechanical penetrations are made into a room. The panel should be designed to allow easy removal and DECON of the area during decommissioning.

(2) Penetrations through walls, ceilings, and floors should be sealed.

c. Portable Shields and Enclosures. To minimize the costs associated with the construction and decommissioning of permanent partitions and shield walls, the facility can be constructed with fewer such walls, provided sufficient space is provided for:

(1) The use of temporary or portable enclosures during maintenance periods.

(2) The use of temporary shielding. For ALARA purposes, the temporary shield should be capable of being transported into the area in lieu of building the shield in

place. Also, the temporary shield should be covered to prevent contamination.

4-4. Mechanical, electrical, and heating, ventilating, and air conditioning systems design criteria

For each nuclear facility under design development, the following options should be evaluated:

a. Pipes and Ducts. Design and placement of pipes and ducts should allow easy access, cleaning and removal.

(1) Pipes, ducts, and equipment which potentially could be contaminated should not be embedded or sealed in walls, floors, or ceilings. Plan to allow access and removal of such systems.

(2) Pipes which potentially could be contaminated should not be run below concrete slabs on grade. Such pipes should be run in chases or trenches and be accessible through removable hatches or panels.

(3) Pipes and ducting which potentially could be contaminated should be kept as short as possible, and should not be routed through areas of lesser contamination.

(4) Flushing connections should be quick-disconnect type and should be provided on potentially highly radioactive systems so that the entire system or selected portions of the system can be easily flushed. The flushing water system should be separated from the radioactive system during normal operations.

b. Sumps and Drains. Design and placement of sumps and drains should prevent the spread of radioactive contaminants and facilitate cleanup.

(1) Sumps which potentially could be contaminated should be doubled walled to provide secondary containment. The sump walls should not be bolted. Seams should be minimized and welds ground flush.

(2) Connections should be provided at appropriate locations to ensure complete drainage of a system after shutdown. Vents should be provided to permit draining.

(3) Drains can be equipped with quick disconnects so hoses can be connected to direct liquids to a contaminated sump in lieu of permitting radioactive liquids to run across the floor to a drain.

(4) Pumps should be equipped with collection pans for leakage.

(5) Loop seals should be provided in drains where they enter a sump.

(6) Drains should be routed to appropriate sumps. This routing should consider the fluid quality (including high- or low-level activity or requirements for chemical treatment).

(7) Drains which enter sumps should be designed so that piping extends below the minimum water level to ensure that air-borne activity will not pass to other areas through the drain system.

c. Tanks. Tank locations and connections with operating systems should be selected to minimize spread of contaminants.

(1) Tanks containing contaminated fluids should not be buried but placed in above grade rooms. If this cannot be accomplished, the following alternatives are acceptable:

(a) Tanks can be placed in a buried concrete vault with a sump that allows remote pumpout. In addition, the vault should be coated, sealed, or lined to prevent both in and out leakage. Access should be provided to allow decontamination of the interior surface of the vault.

(b) Tank can be buried if a double-walled design is used. The area between liners should be monitored to provide an early indication of leakage. The design and method of installing the buried tanks should facilitate their removal (e.g., buried tanks should not be tied into other structural members.)

(2) Overflow lines from tanks containing radioactive liquids should be routed to a contaminated sump or collection tank.

(3) Vent lines from tanks containing radioactive liquids should be connected to the contaminated ventilation-system exhaust upstream of the filtration equipment. This will minimize both in-plant airborne activity and plant releases.

d. Integration of Radioactive and Clean Facility Areas. Planning and proper design can minimize the area of a facility which can be exposed to contamination. The following are examples of how isolation and separation should be used to prevent the spread of contaminants:

(1) Uncontaminated systems should not receive influents from contaminated areas.

(2) Equipment should be grouped based on activity inventories and process stream so that higher radiation areas may be segregated from non- or lesser-radiation areas and to minimize runs of interconnecting radioactive piping.

(3) Drains from "clean equipment" in contaminated areas should be treated as contaminated. All floor drains in potentially contaminated areas are to be treated as containing contaminated fluids and are not to be cross-connected with floor drains from clean areas.

(4) If radioactive and nonradioactive systems must be interconnected, connections must be isolated by a check valve and a stop valve. Connections to potable water systems will be protected by an air gap or by two American Water Works Association approved, positive displacement, backflow prevention devices placed in series. Consideration should be given to the use of a quick-disconnect hose system when the lines are small enough.

(5) Consideration should be given to providing separate ventilation systems for contaminated and clean portions of a facility.

(6) Air flow must always be from areas of lower radioactivity to areas of higher radioactivity. However, differential air pressures resulting from flow balancing to ensure the proper air flows must not be so high as to make it difficult to open doors.

e. Crud Traps. Crud traps are those features in the design of fluid systems that promote the buildup of radioactive material. These should be eliminated to the greatest degree possible. This will reduce personnel exposure not only during periods of operation and maintenance but also during decommissioning. Design features that would eliminate or reduce the number of crud traps are:

- (1) Instrument taps that come off the side of piping.
- (2) Drain connections that are designed to minimize crud collection or provisions to open valves periodically to flush any collected radioactive material to the waste-collection tank/pump.
- (3) Lines that are sloped to drain points so that crud can be flushed.
- (4) Long radius bends on radioactive systems and resin-transfer systems.
- (5) Orifices located in vertical runs of pipe rather than in horizontal runs.
- (6) Tanks provided with sloped bottoms and a bottom drain.
- (7) Loops that are above rather than below the pipe run when thermal expansion loops are required on piping.
- (8) Piping that is sloped in the direction of flow.
- (9) Unavoidable deadlegs on process systems that are designed so that crud can be flushed out by opening a valve.
- (10) Piping that is butt-welded as much as practicable without use of backing rings. In additions, socket welds should be avoided where possible since they are also crud traps.
- (11) Valve selection that is based on minimum internal dead spots and crevices where crud will accumulate.
- (12) Radioactive waste sumps are referenced throughout this text. This is to ensure the general applicability of this manual. However, some facilities may use waste-receiver tanks to collect inputs from equipment and floor drains. Whether a drainage system feeds a tank or a sump, the guidance relating to designs to enhance decommissioning is applicable.

f. Ventilation. The ventilation system shall be the primary means by which the spread of airborne contamination is minimized and controlled.

- (1) Proper design of the ventilation system is critical in that it must ensure that clean areas do not receive contaminated air flows due to perturbations in the ventilation system resulting from such incidences as doors in other than their normally intended position either open or closed, roof plugs, floor plugs or access hatches being open, or temporary isolation of any part of the ventilation system.
- (2) Filters should be located as near to the ventilated area as possible to minimize contaminated ductwork. Filter maintenance area should be designed to allow easy access and removal of contaminants.
- (3) High Efficiency Particulate Accumulator (HEPA)

filters should be used on the exhaust from areas expected to have high airborne activity. Where necessary, roughing filters should be located upstream to prevent premature loading of the HEPA filters.

(4) Outside filters should be provided on the ventilation intakes to reduce the dust loading on the contaminated exhaust filters.

(5) If a component can generate high airborne levels, local filters should be provided on exhaust vents from the component or the component area prior to tie-in with the main ventilation system. This minimizes downstream contamination.

(6) Consideration should be given to frequent air changes and filtering in areas where radioactive gases are expected in order to minimize contamination and subsequent migration of such gases.

(7) Normally closed cubicles should be designed with ventilation hookups to control ventilation flow prior to opening the cubicle.

(8) Air locks may be used where appropriate.

(9) Seams and joints in fume hoods and ventilation ductwork should be kept to a minimum and should be sufficiently tight to prevent leakage.

g. Electrical and Equipment. Design and placement of electrical systems and equipment should allow isolation from contaminants where possible or facilitate removal and cleaning during decommissioning.

(1) All equipment subject to contamination should be designed for easy and effective decontamination; it should be easily disassembled to permit access to contaminated portions.

(2) When possible, electrical connections on equipment in high radiation/contamination areas should be of a quick-disconnect type.

(3) Equipment such as transformers, switchgear, motor control centers, and panelboards should not be installed in areas subject to contamination.

(4) Cable trays should be enclosed to limit their contamination.

(5) For equipment to be moved, a path should be provided which allows for straight lifts and runs that do not allow the contaminated equipment to pass into or over uncontaminated areas.

(6) For situations where large components are not accessible by mobile cranes, the placement of permanent jib, bridge, or monorail cranes should be considered to facilitate disassembly and removal.

(7) For medium and small components, pad-eyes should be installed so that rigging can be easily used.

(8) Components should be provided with appropriate lugs to minimize rigging setup time.

(9) Lighting Fixtures should be sealed and flush with the ceiling.

(10) When redundant power sources are required, cable tray routings to critical equipment should be independent.

4-5. Radioactive waste handling

The handling, sorting, processing, packaging and temporary storage of LLW is an integral part of any decommissioning program. This section discusses provisions which should be adopted in the facility design which will facilitate LLW handling during decommissioning.

a. Process Design Provisions. Where applicable, areas should be provided for large shredders capable of shredding thin wall pipe and sheet metal, compactors, and LLW processes including mobile incinerators, liquid-waste processing assemblies, and solidification systems. Design provisions for these processing areas are:

(1) Access paths that are as direct as possible without unnecessary passage through clean areas.

(2) Processing area ventilation releases that are treated or filtered before they are discharged to prevent contamination of nearby clean areas.

(3) Processing areas that are capable of confining any accidental liquid release, thus preventing the contamination of any adjacent clean area. The net containment volume should be at least 125 percent of the total volume of liquid contained in the area.

(4) Services required for LLW processing areas would include HYAC, lighting, electrical power, instrument air supply, demineralized water, and compressed air.

b. Process Space Requirements. Specific guidance cannot be provided for the space and support services required for the various LLW processes that could be used in support of a decommissioning effort. Such process requirements are facility dependent. Also, attempts to define the LLW processing requirements should be initiated during the conceptual design development for the facility when the initial decommissioning plan is started. For information, some space requirements are as follows:

(1) *Mobile Incineration.* Low level waste mobile incinerators require space for three standard trailers, approximately 30 by 60 feet. These trailers provide the incinerator, pollution abatement system, control room, and packaging area for the ash. Space must still be provided for sorting of the LLW feed to the incinerator and storage, until shipping, of the packaged ash.

(2) *Mobile Solidification.* Space is required for a cement carrier with some cement metering equipment, approximately 10 by 50 feet and for a standard lowboy transporter with a shielding cask on board, approximately 10 by 40 feet. Finally, space is required for a mobile crane to remove the shipping cask lid and space to lay down the lid.

(3) *Super Compactor.* Space is required for one standard tractor-trailer truck, approximately 10 by 40 feet. This provides for the compactor only. Space for preparation of the compactor feed and storage of the compacted waste is additional.

(4) *The Equipment Identified Above is the Largest Equipment.* Much of the other equipment including shredders and demineralizers require space envelopes of 12 by 12 feet or less. However, provisions for shield

walls, access, and cranes must also be addressed when the decommissioning approach is developed and provisions to accommodate the LLW processes are defined.

4-6. Decontamination

This section defines those provisions that can be made during the initial planning of a nuclear facility to facilitate its later decontamination.

a. Fluid Systems. The decontamination of fluid systems may be necessary to support the decommissioning of a given facility. Upon completion of the preliminary piping systems designs, a review of the designs should be made with the following objectives:

(1) Based on the processes performed at the facility, identify the types of decontamination processes that should be used in the various fluid systems.

(a) High chemical concentration DECON.

(b) Low or dilute chemical concentration DECON.

(c) Mechanical DECON.

(2) For each decontamination process selected, the applicable portion of the fluid system should be segmented providing the boundary for each independent decontamination application. With the chemical decontamination processes, it may only be necessary to divide the appropriate portion of the system into a few discrete decontamination segments. However, for mechanical processes, several discrete decontamination segments might be necessary.

(3) Provide for the addition of any new valves needed to accomplish the desired segmenting of the fluid systems.

b. Support Requirements for Chemical DECON of Fluid Systems. Space or fittings should be provided for the future installation of equipment and temporary piping for in-place chemical cleaning of contaminated fluid systems. Examples of the types of equipment, temporary piping tie-ins, and process capabilities that will be required are given below.

(1) Facilities to mix and prepare the chemical solutions. These may be temporary skid-mounted assemblies.

(2) Heaters to raise the solution to the proper temperature.

(3) Fittings to fill and drain the system being decontaminated.

(4) The ability to bring the entire fluid system being decontaminated to the proper process temperature.

(5) Fittings to allow feed and bleed to and from the system being decontaminated.

(6) The ability to purge, with demineralized water, any component that might be adversely attacked by the chemicals and thus fail during the decontamination process. For example, reactor coolant pumps may use stellite seals. During a decontamination, these pumps would be used to recirculate the chemical solution. However, the chemicals would attack the seals. The seals can be protected by a water purge past the seals.

(7) The ability to collect and process waste. (The requirements depend on the chemical process selected.)

(8) Adequate space for recirculation pumps, motor control centers, instrumentation, and control panels.

(9) The ability to rapidly drain the system in order to prevent or mitigate an accident.

(10) This list does not provide all the interfaces that would be required when performing a chemical decontamination. It does, however, identify space provisions that should be accounted for during initial design efforts but that would be almost impossible to provide once the facility was built. In a similar manner, the fittings called for here are easier to install during construction rather than after the system has been installed and becomes contaminated.

c. *Support Requirements for Mechanical DECON of Fluid Systems.* Provisions that should be considered for the in-place mechanical cleaning of fluid systems are as follows:

(1) Necessary fittings to allow the insertion and removal of mechanical decontamination tools such as pigs, brushes, or scrapers should be provided.

(2) Pipe bends should be smooth with large radius bends. This design criterion is limited to the contaminated process pipes, not utility pipes.

(3) Electrical supply, compressed air supply, and demineralized water supply should be provided as necessary.

(4) The ability to collect and process flushwater resulting from decontamination activities.

d. *In Place DECON of Surfaces.* Provisions that should be considered for the in-place decontamination of surfaces are:

(1) Adequate electrical outlets for air samplers as well as electrically operated tools.

(2) Compressed air outlet for air-operated tools.

(3) Convenient demineralized water outlets for foam or hydrolaser decontamination equipment.

(4) Adequate and appropriate drains if chemical or hydrolaser decontamination is planned.

(5) Means for the collection, storage, and processing of wastes.

e. *Remote DECON Provisions.* Processes such as electropolishing, freon cleaning, and grit-blasting are likely decontamination processes to be used in support of a decommissioning. These processes could be called remote decontamination processes in that the item to be decontaminated is normally brought to a processing area rather than decontaminated in place. Provisions that should be considered for the remote decontamination processes are:

(1) A central decontamination area design to prevent the airborne release of radioactive material and to contain any liquid spills.

(2) The design should allow materials to be easily moved to a central decontamination area. The transport path should be as direct as possible without unnecessary passage through uncontaminated areas.

(3) Material-handling equipment should be provided in the central decontamination area. Some components will have to be lowered into, and removed from, decontamination tanks or booths.

(4) Liquid decontamination wastes will have to be collected and transferred to the waste processing area.

(5) Provisions will have to be made for electrical power, compressed air, and demineralized water supplies.

4-7. Fire protection

Fire protection requirements are placed on both the facility at which the decommissioning effort is directed and any temporary onsite process and LLW storage facilities in support of the decommissioning effort. In addition, should the fire protection system be activated, preventive measures must be taken to restrict the spread of contaminants.

a. *Facility.* The decommissioning should progress in such a manner that the fire-protection system installed for normal facility operation remains intact and operable up to the point that the facility is totally decontaminated. The need to maintain fire protection from this point on depends on:

(1) Whether or not the facility is to be reused.

(2) The time interval between complete decontamination and demolition of the facility.

(3) Requirements to protect any adjacent building or facility.

(4) Requirements imposed by site fire marshals.

b. *Temporary Process and LLW Storage.* The potential fire hazard created by the use of temporary process and decontamination equipment exists and thus fire protection must be provided to process areas. Additionally, temporary LLW storage areas must be protected from fires to prevent a situation where the spread of contaminants is likely. Such temporary facilities may require:

(1) Installation of fire and smoke detection equipment.

(2) Extension of the existing fire protection system if automatic protection is necessary.

(3) Installation of a manually operated fire protection system.

c. *Containment Systems.* Where sprinkler or other liquid-type fire suppression systems are used, containment systems must remain intact and capable of retaining and storing the volume of contaminated liquid produced by a 15 minute flow of the suppression system.